

## 1.0 INTRODUCTION

### 1.1 OVERVIEW

This manual was written to assist dam owners, inspectors, and qualified dam safety professionals in inspecting dams and maintaining them in a safe and stable condition. Dams are complex structures and usually require a multi-discipline approach to adequately address inspection, maintenance, and other safety issues. Therefore, dam owners should always obtain proper professional help when inspecting and maintaining dams and their appurtenant works.

The primary focus of any dam safety effort is the protection of lives and property in the area downstream from the impoundment. Every owner should be aware of the potential hazard that his\her dam poses to the inhabitants and property and of the need to properly maintain the dam in such a way as to reduce this hazard as much as possible. The liability for damages resulting from a dam failure rests with the owner of the dam.

A good safety inspection and maintenance program is also important to the owner's bottom line. The typical dam represents a considerable cash investment. Replacement or major repair costs could be high. Loss of the dam could result in the loss of a water source, recreational facility, flood protection, or other assets.

It is important for the dam owner to recognize that dam safety inspections alone do not make dams safe. Dams require an on-going inspection and maintenance program to insure their continued safety and useful life. This fact is not always fully appreciated. Often there is a tendency to neglect dams once construction is completed.



Figure 1-1 Dams are commonly used to provide recreational resources and can enhance property values, but they must be properly maintained to realize their potential.

This manual presents a logical approach that should be followed to evaluate the safety of dams in Indiana. Its intent is to inform the dam owner, operator, or others of general aspects of dam safety inspections, operation, and maintenance so that they can recognize certain unsafe conditions that may be associated with their structures. If unsafe conditions are recognized, professional services may be required to assess the problem and to take appropriate remedial action. This manual provides general guidance on some of the more common problems, but it is not intended to cover every type of condition, situation, or emergency that could possibly cause a dam to become unsafe or fail.

This manual may also be used as a reference to qualified dam safety professionals with

expertise in dam design, construction, and inspections. Some of the information presented in the manual may be basic knowledge to these individuals, but the inspection procedures, documentation, and reporting should be followed by all.

The design of a dam is the task of an experienced professional engineer. The implementation of major remedial measures for a dam generally requires the help of an experienced professional engineer or a qualified dam safety professional. The application of trial-and-error "home remedies" to dam problems is not recommended and such an approach may prove to be far more costly than obtaining and acting on professional guidance. The text and illustrations of this manual are not intended to serve as a design guide either for the construction of new dams or for extensive remedial measures for existing dams. Rather they are intended to serve as a source of information which the owner can use in his/her regular maintenance and inspection activities and as a general guide as to when professional services are needed to insure the safety of a dam.

## **1.2 DAM SAFETY LAWS**

The Indiana General Assembly has established dam safety laws to protect the citizens of Indiana. Generally, the laws are intended to insure that the dam owner maintains his/her dam in a safe manner. The laws also define inspection requirements, violation conditions, and actions that the Indiana Department of Natural Resources (IDNR) will take if the dam owner violates the law. IDNR currently regulates all dams that meet any one of the following criteria:

- (1) the drainage area above the dam is greater than 1 square mile
- (2) the dam embankment is greater than 20 feet high
- (3) the dam impounds more than 100 acre-feet

All dams that meet any one of these criteria will be regulated by IDNR under Indiana Code (IC) 14-27-7.5, "Regulation of Dams." IC 14-27-7.5 presents the legal requirements for operating, maintaining, and inspecting regulatory dams in Indiana. A copy of the current Indiana Code for the regulation of dams is contained in Appendix A of Part 1. The most recent version of the statutes can be found on website of the Indiana General Assembly. All dam owners should read and maintain a copy of the current Indiana Code for the regulation of dams in their dam safety file.

The primary focus of the dam safety laws is that dam owners are responsible for keeping their dam safe and for operating it in a manner that minimizes potential safety risks to downstream lives and property. Dam owners can be held accountable for any damage that results from the failure of their dams, so they should do whatever is necessary to avoid injuring persons or property. As stated by Professor Denis Binder in *Legal Liability for Dam Failures*, "It is clear that compliance with a generally accepted industry or professional standard of care, or with government regulations, establishes only the minimal standard of care. Courts may assess a higher standard of care,

utilizing the "reasonable person" standard and foreseeability of risk as the criteria. It is fair to say that persons who rely blindly upon a governmental or professional standard of care, pose great danger to others, and present a legal risk to themselves, when they know or reasonably should know that reasonable prudence requires higher care."

Even if a dam does not fall under IDNR jurisdiction, it would be prudent for all dam owners to develop a dam safety program that includes safety inspections, and an operation and maintenance plan.

If a dam does fall under IDNR jurisdiction, a permit will be required to construct or modify the dam or its appurtenant structures. During the permit application process, IDNR will review the information provided by the dam owner for adequacy. The owner's designer is responsible for the safe design of all components of the dam and appurtenant works. IDNR has specific guidelines (see Subchapter 1.7, Part 1) that assist in the design and construction of the dam.

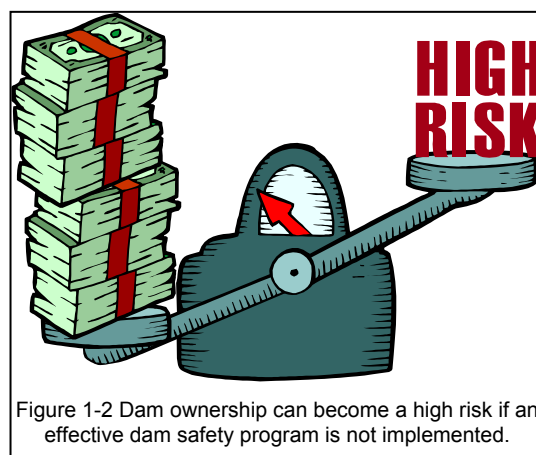
### 1.3 IMPORTANCE OF DAM SAFETY

The storage of water is a potentially hazardous activity; it creates increased risk to lives and property situated downstream of the dam. The owner of a dam is responsible for operating and maintaining the dam in a safe manner to prevent harm to others and their property. An uncontrolled dam breach can cause serious property damage and injury or the loss of life downstream, depending on the size of the reservoir and the type and location of buildings or other structures. It is therefore very important for dam owners to establish and maintain an effective safety program that includes safety inspections, operation, maintenance, and upgrades (as required) of the dam and reservoir.

Although not the focus of this manual, it should be pointed out that the dam owner is also responsible for unsafe conditions within and around the reservoir that could result in injury or loss of life to people who use or visit the reservoir. Steep slopes, sinkholes, depressions, or excessive vegetation could lead to accidents that cause serious personal injury.

All dams, including dams that fall under IDNR jurisdiction, should be operated and maintained in a safe manner. Under Indiana law, IC 14-27-7.5-7, "Maintenance and repair; duties of owner," the owner of a structure shall maintain and keep the structure in the state of repair and operating condition required by the following:

- (1) the exercise of prudence
- (2) due regard for life and property



- (3) the application of sound and accepted technical principles

The dam owner may be held liable for property damage and personal injury and for failing to prevent such mishaps.

## 1.4 RESPONSIBILITIES OF DAM OWNERSHIP

### 1.4.1 Overview

Dam ownership imposes significant legal responsibilities and potential liabilities on the dam owner. The dam owner should be aware of the potential liabilities and learn how to deal with these liabilities.

This subchapter presents general legal and insurance matters to help dam owners minimize their exposure to liability due to dam ownership or operation. It is intended only as a general introduction to the many issues regarding dam owner liability. This manual does not present answers to specific legal issues. Dam owners and operators should obtain competent legal counsel when dealing with specific issues. Dam owners should always act as if they are liable if there is any doubt.



Figure 1-3 The dam owner is responsible for repairing this damage downstream of the dam.

### 1.4.2 Potential Liability Issues

The responsibility for maintaining a safe dam rests with the owner. A dam failure resulting in an uncontrolled release of the reservoir can have a devastating effect on persons and property downstream. Safely maintaining a dam is a key element in preventing a failure and limiting the liability that an owner could face. The general rule is that a dam owner is responsible for its safety. Dam owners should consult with their own experienced attorneys for specific legal advice concerning liability and financial responsibility to those who may be affected by dam safety issues.

The failure of a dam has the potential for catastrophic impact on communities, private property, and public works downstream. Experience reveals that the failure of even small dams can result in serious injuries, fatalities, and extensive property damage. The dam owner loses a valuable asset, and faces reconstruction costs and possible liability for downstream damages. Local communities may be directly impacted due to building damage, injuries, fatalities, lost water supply, damaged transportation and infrastructure, and lost recreational assets.

The extent of an owner's liability will vary, depending on the statutes and case law precedents. The concept of strict liability imposes liability on a dam owner for damages that occur regardless of the cause of failure. The alternative theory of negligence considers the degree of care employed by the owner in constructing, operating, and maintaining a dam. Historically, courts have sought to compensate those injured by a dam failure.

When assessing liability, the standard of care exercised by an owner will be closely examined. The standard of care should be in proportion to the downstream hazards involved. Where the risk is great, owners must be especially cautious.

Compliance with government or professional standards does not absolve an owner from liability, but it does establish a minimum standard of care to be used by owners. The extent of liability in any situation depends on the facts of the case and how those facts are interpreted by a judge or jury. Consequently, actions that result in owner liability in one case may not result in liability in different cases. In general, a dam owner is required to use "reasonable care" in the operation and maintenance of a dam and reservoir.



In today's litigious society, it is safe to assume that in the case of a catastrophic dam failure, extensive litigation will ensue. Any competent lawyer, representing the victims will sue all possible wrongdoers in seeking redress, including the owners and operators of the facility, and possibly the architects, engineers, contractors, sub-contractors, and consultants involved in the original construction and any subsequent modifications.

An essential and logical part of an organization's management program is the control of potential losses that may arise. To manage risks, an owner can utilize a combination of standard operation procedures, employee training, regular maintenance, emergency preparedness, and liability insurance. A dam owner can take several actions to protect against financial loss.

To help minimize dam owner liability, every dam should have:

- a state dam safety permit (if applicable)
- a management and maintenance plan, and an emergency action plan (if lives and property are at risk)
- documented periodic inspections



- warning signs and controlled access.

### **1.4.3 Environmental Concerns**

A dam owner needs to be generally aware of potential environmental issues before a dam is constructed or purchased, or its method of operation is altered (some of these areas of concern are discussed below). The dam owner should carefully consider the possible impacts of dam operation and how it affects the environment. He/she should seek professional help for a full evaluation of potential environmental problems.

Within the reservoir, it is likely that sediments have accumulated over the years. Release of these sediments downstream by operation of the dam, changing the reservoir level, or removing the dam could result in significant damage and liability to the dam owner. In addition, release of sediments downstream could adversely impact plant and wildlife for significant time periods. It is also common that the sediments contain pollutants.

Large discharges that can result from an uncontrolled dam breach can cause serious environmental damage downstream. These flows can cause severe erosion and can carry the sediment into receiving streams and other water bodies. Large discharges can destroy fish spawning beds, bird nesting areas, plant life, and other aquatic habitat. Man-made structures can also be damaged or destroyed by such discharges.

This manual addresses dam safety issues, however, the dam owner should contact the appropriate government agency for potential environmental issues.

### **1.4.4 Insurance**

The purpose of this subchapter is to provide dam owners with general information about dam insurance. The primary purpose of dam insurance is to share the risk and protect the assets and financial well being of the dam owner. Insurance cannot make a dam safe, or make an inherently faulty construction or renovation project into a good one. Inadequate coverage or insufficient limits on that coverage, coupled with a major loss, can mean the financial ruin of a dam owner. In order to obtain insurance and get a reasonable rate, the dam owner may have to show that the dam meets acceptable standards with regard to design, construction, and operation.

## **1.5 DAM SAFETY INSPECTION REQUIREMENTS**

A dam safety inspection program should include four types of dam safety inspections:

- (1) formal technical inspections,
- (2) maintenance inspections

- (3) informal inspections
- (4) special inspections

A formal technical inspection is the most comprehensive form of inspection and usually includes a review and analysis of available data and plans, a field examination, and preparation of a report. A key component of a formal technical inspection is the compilation or review of all available information for the dam and the surrounding area. Formal technical inspections should be performed by a team of one or more professional engineers, geologists, or qualified technicians, accompanied by the dam owner or his representative. Composition of the group is determined by the type of dam and its appurtenant works, the condition of the dam, and any statutory requirement.



Figure 1-5 Embankment dam with a concrete riser is a common type of dam requiring inspection in Indiana.

A maintenance inspection is a preventive measure designed to identify problems and to develop solutions to prevent further degradation. Maintenance inspections generally involve reviewing previous inspection reports, performing a field examination, and completing a report form or inspection brief. Maintenance inspections are usually performed by the dam tender, maintenance staff, or the dam owner.

In the case of an informal inspection, the evaluation process typically consists of a field examination and completion of a report form or inspection brief. An informal inspection can be conducted at any time, and may include only portions of the dam or its appurtenant structures. Informal inspections are usually conducted by project personnel or dam owners as they operate the dam to monitor known problem areas, or to provide an update on site conditions between maintenance and technical inspections.

A special inspection may need to be performed to resolve specific concerns or conditions at the site on an unscheduled basis. Special inspections may be conducted following severe storm events, earthquakes, or other incidents which could affect the integrity of the dam. These inspections may also be part of a response to an emergency situation, such as rising reservoir levels during a storm, or excessive seepage resulting in piping. These inspections are usually performed by the dam owners, maintenance personnel, or qualified dam safety professionals.

Dam inspections are typically referred to as safety inspections since they are intended to help protect the safety of people and property downstream by providing a means of evaluating and maintaining the dam's integrity. Part 3 of the Indiana Dam Safety Inspection Manual presents procedures and information on conducting dam safety

inspections.

## **1.6 DAM HAZARD CLASSIFICATION SYSTEM**

As defined by Indiana Law, "hazard classification" means a rating assigned to a structure by the department (IDNR) based on the potential consequences resulting from the uncontrolled release of its contents due to a failure or wrongful operation of the structure.

Indiana currently places all dams into one of three hazard classifications:

- (1) High hazard: A structure the failure of which may cause the loss of life and serious damage to homes, industrial and commercial buildings, public utilities, major highways, or railroads.
- (2) Significant hazard: A structure the failure of which may damage isolated homes and highways, or cause the temporary interruption of public utility services.
- (3) Low hazard: A structure the failure of which may damage farm buildings, agricultural land, or local roads.

The hazard classification of a dam is determined by evaluating the area that would be affected by inundation in the event the dam fails. A correlation between the amount of inundation and the hazard classification is summarized on the table in Part 1, Appendix B. In many cases, the hazard classification of a dam can be determined by a review of current topographic maps and a visual inspection of the downstream floodplain for a distance commensurate with the size of the reservoir. If a breach analysis is required to determine the area of inundation, methodology accepted by IDNR should be used.

The dam spillway design is based on the hazard classification. IDNR has specific spillway design guidelines which must be followed to obtain a permit for a new dam, or to obtain a satisfactory rating for an existing dam. In general, a high hazard dam must be designed to safely pass 100% of the PMP storm event, and a significant or low hazard dam should safely pass 50% of the PMP storm event.

Over time, development may occur in the area downstream of a dam. In fact, a manmade lake sometimes encourages downstream development. If a new dam is being planned, it may be prudent to design the dam spillway for a higher hazard classification. This can help the owner avoid major dam and spillway modifications at a later date in the event that downstream development occurs, the hazard classification increases or land availability may be restricted.



## 1.7 GENERAL GUIDELINES FOR NEW DAMS & IMPROVEMENTS TO EXISTING DAMS IN INDIANA

<b>Table 1-1 Table of Contents</b> <i>General Guidelines for New Dams &amp; Improvements to Existing Dams in Indiana (2001 Edition)</i>		
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The Indiana Department of Natural Resources, Division of Water prepared the *General Guidelines For New Dams & Improvements To Existing Dams In Indiana* for project engineers, technical professionals, and owners involved in the design and construction of dams or the modification of existing dam's that are under the jurisdiction of the IDNR. The intent of these guidelines is to provide direction to experienced dam design professionals so that the final product, the dam, is safe and the owner's investment in professional engineering is maximized.

The majority of information given in the guidelines document is general and provides many of the dam safety technical principles used throughout the country. The Project Engineer in charge of the design of a dam must be a registered professional engineer and have the training and experience to properly apply these guidelines to the specifics of the site and the needs of the owner. If the owner's Project Engineer follows these guidelines and an appropriate engineering design package is submitted to IDNR's Division of Water, the time to obtain approval on the proposed work will be significantly reduced. A committee of 17 professionals from the private engineering community and IDNR contributed significant time to the development of the guidelines.

The guidelines are useful for the design of small to medium sized dams with the following typical characteristics:

- An earth embankment with appurtenant works constructed to remain stable under a variety of loading conditions for the design life of the structure.
- A properly sized principal spillway that will convey the runoff from normal rainfall events.
- An emergency spillway channel placed an adequate distance from the earth embankment that will operate infrequently and safely pass runoff from the design storm without overtopping the dam.

Because each project requires site specific considerations, the guidelines should not be

viewed as a "cookbook" for the design, construction, modification, or repair of a dam. The intent of the document is to outline the general technical data, plans, and engineering computations that need to be submitted with the permit application for the proposed work. If the guidelines are followed, the time necessary for the technical review and approval should be reduced. Guidance on analyses and design issues for innovative, untested, or high-risk dam designs is not covered in the guidelines. The extent of engineering tests, analyses, studies, evaluations, and assessments that are needed to justify an atypical design is beyond the scope of this manual. Further, the time to conduct the additional and extensive engineering analysis and review can be significant when compared to the typical dam described above.

Dams are complex structures that typically require a multidisciplinary analysis and design approach. Over the years, there have been many incomplete engineering submittals to the IDNR that lacked adequate detail in a particular technical area (hydrologic/hydraulic, geotechnical, geological, surveying or structural). The analysis and design of a dam must be supervised by a Project Engineer who is a registered professional engineer. A complete engineering submittal requires adequate technical input and support from hydrologic, hydraulic, geotechnical, geological, structural, and mechanical engineers, as well as licensed land surveyors. It is important for the Project Engineer to consider archaeological and environmental issues in the design or modification of a dam. An understanding of the roles of the various stakeholders is necessary for the design, construction, and operation of a safe dam.

Questions concerning the guidelines should be addressed to the Division of Water at the Indiana Department of Natural Resources, 402 W. Washington Street, Indianapolis, Indiana, 46204. The guidelines are available on IDNR's website for public use at [http://www.in.gov/dnr/water/dam\\_levee/index.html](http://www.in.gov/dnr/water/dam_levee/index.html).